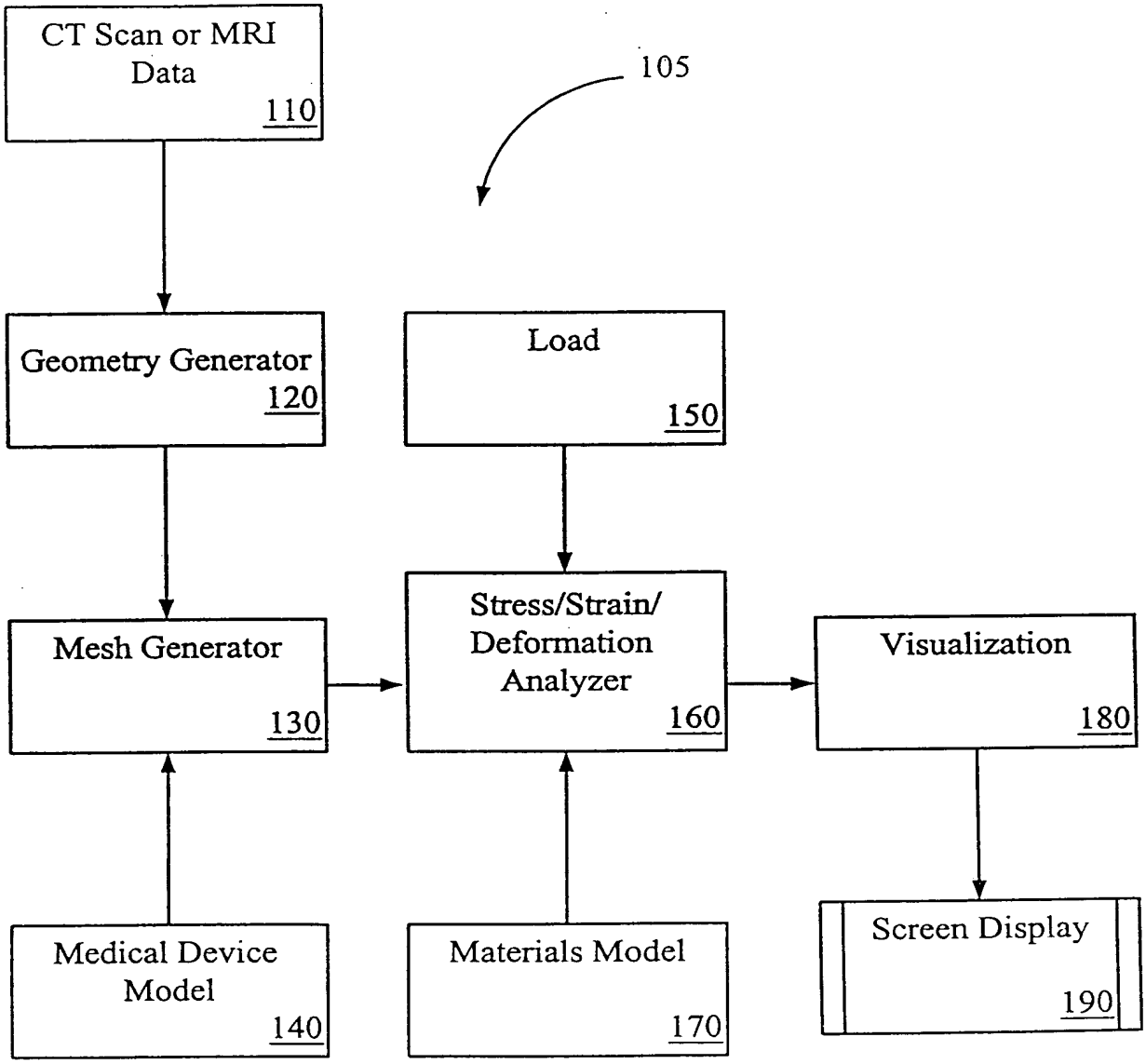

CT Scan or MRI Data
110
105
Geometry Generator
120
Load
150
Mesh Generator
130
Stress/Strain/ Deformation Analyzer
160
Visualization
180
Medical Device Model
140
Materials Model
170
Screen Display
190

FIG. 1

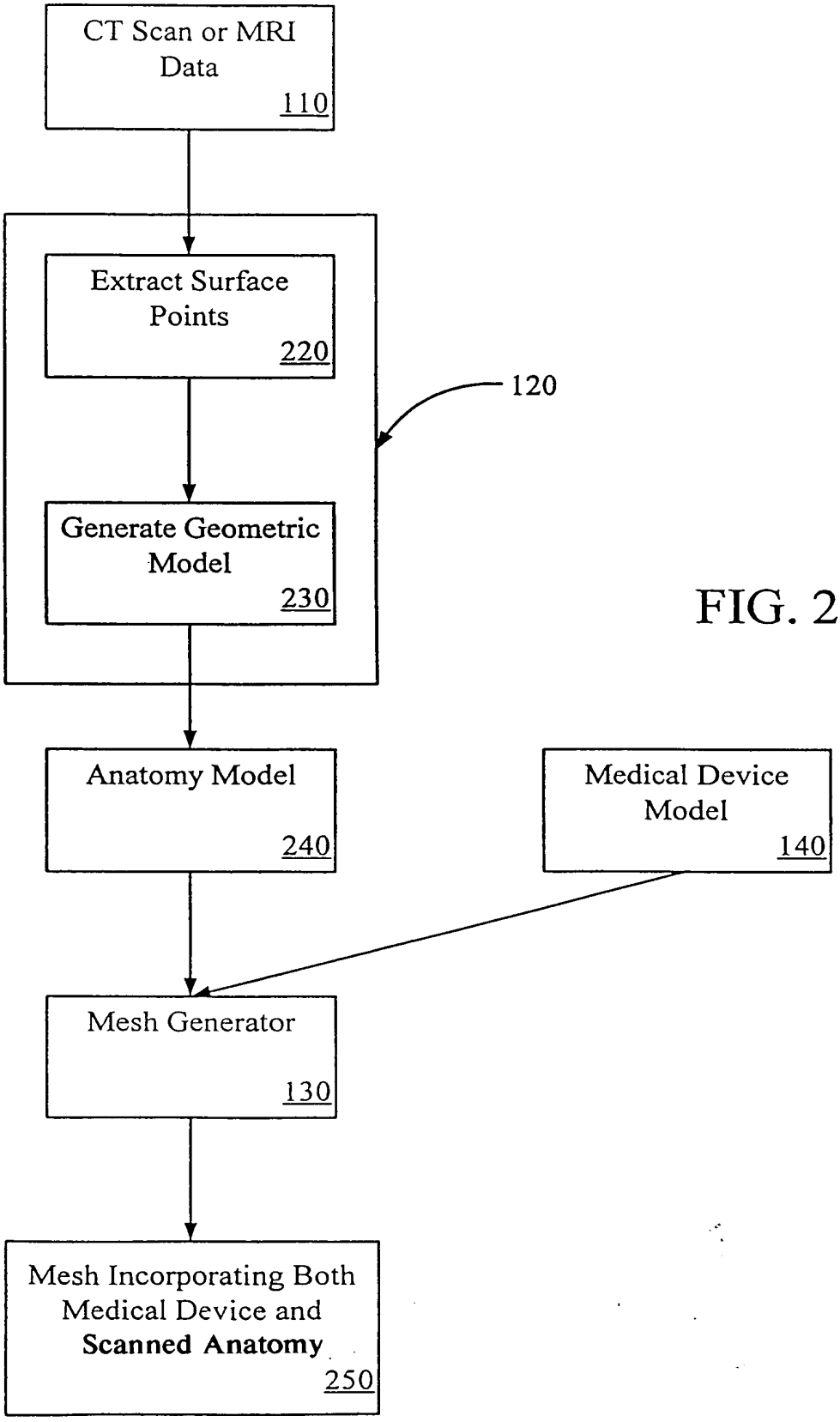

CT Scan or MRI Data
110
Extract Surface Points
220
120
Generate Geometric Model
230
Anatomy Model
240
Medical Device Model
140
Mesh Generator
130
Mesh Incorporating Both Medical Device and Scanned Anatomy
250

FIG. 2

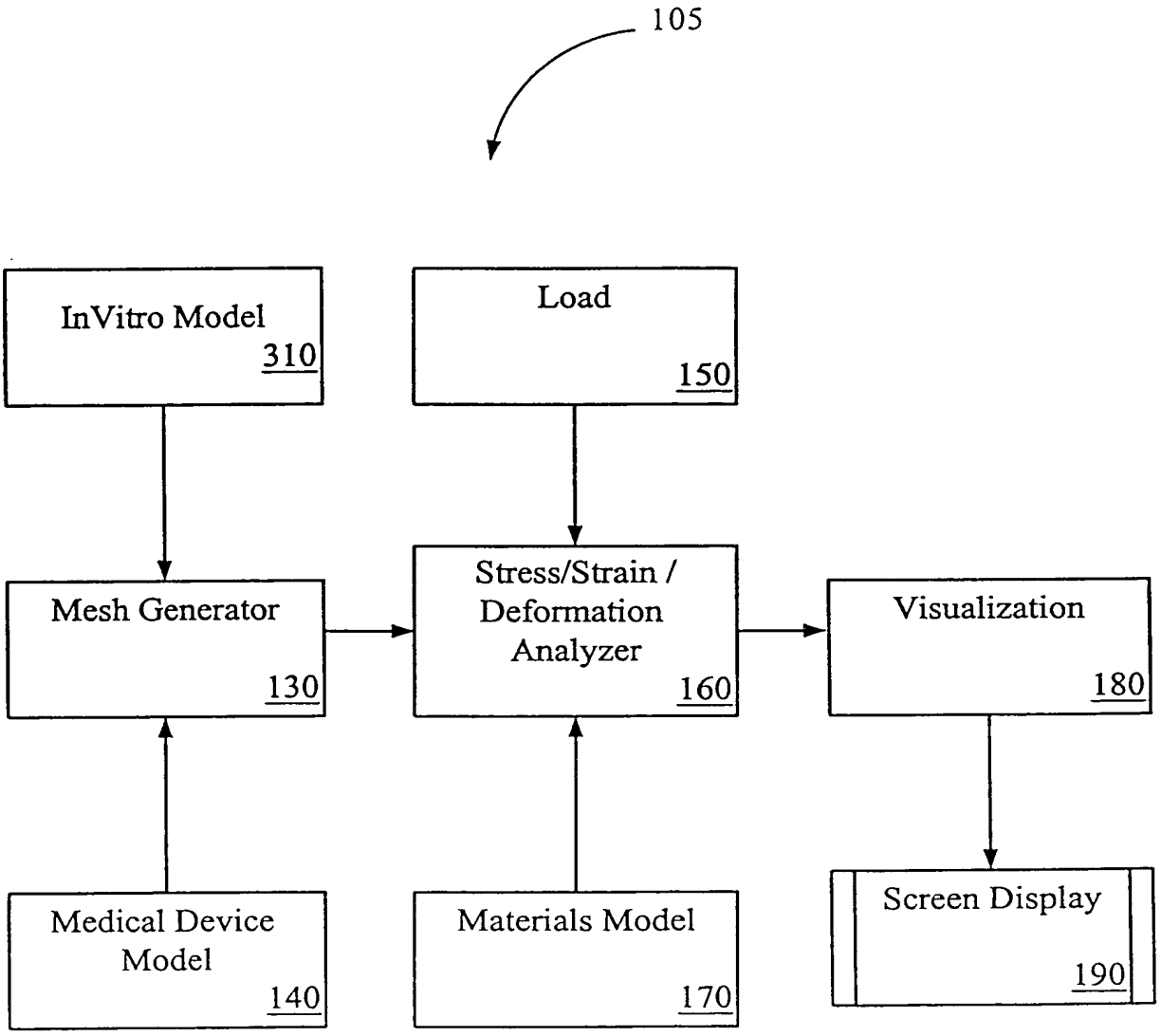

105
InVitro Model
310
Load
150
Mesh Generator
130
Stress/Strain / Deformation Analyzer
160
Visualization
180
Medical Device Model
140
Materials Model
170
Screen Display
190

FIG. 3

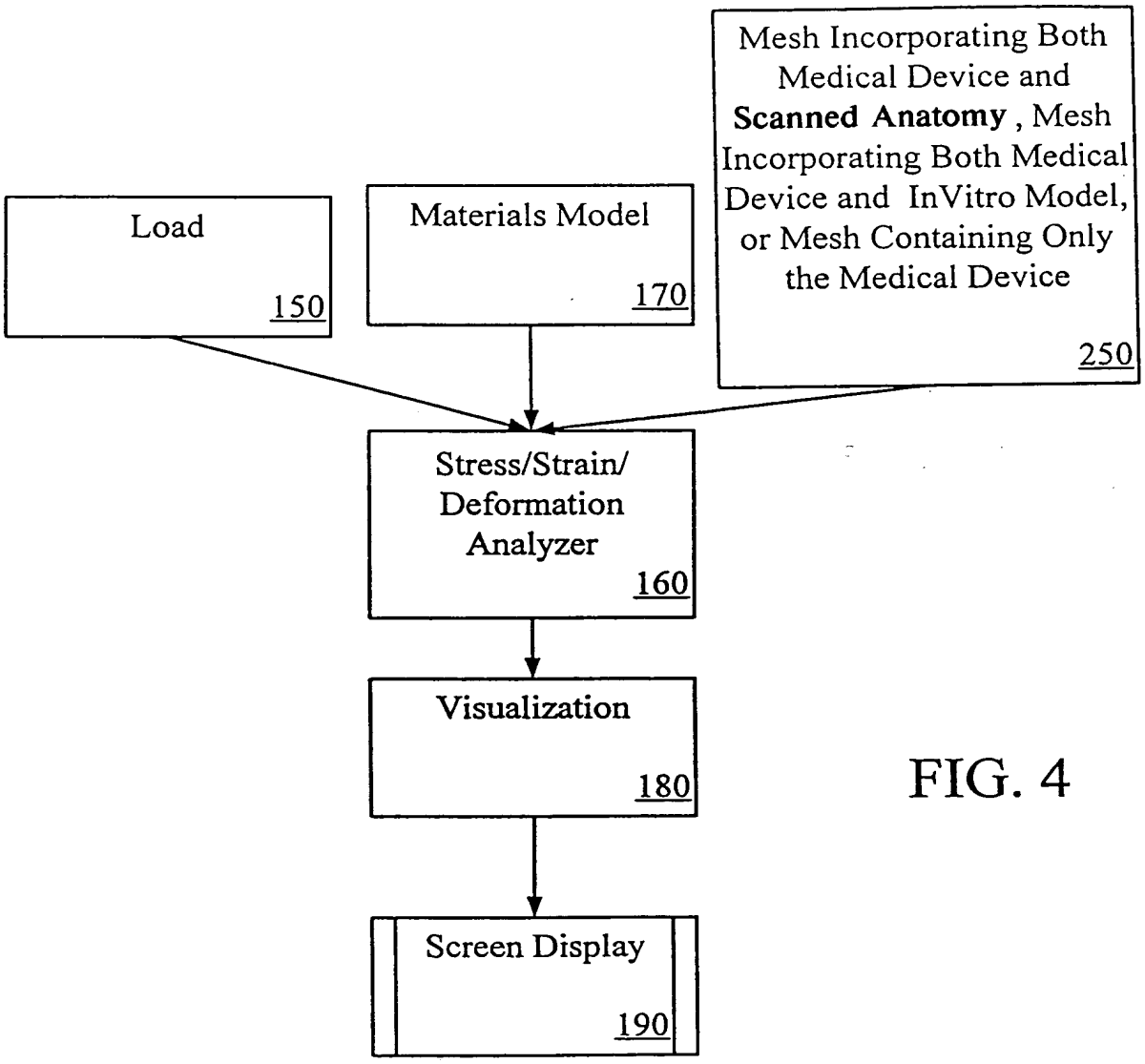

Mesh Incorporating Both Medical Device and **Scanned Anatomy**, Mesh Incorporating Both Medical Device and InVitro Model, or Mesh Containing Only the Medical Device
250
Load
150
Materials Model
170
Stress/Strain/ Deformation Analyzer
160
Visualization
180
Screen Display
190

FIG. 4

FIG. 5A

```
Line  Command
1   c *** Slotted Tube Integrated Stent Design Simulation: istent.run ****
2   c
3   c -------------------- parameter settings -------------------
4   c
5   c .... inike=1 => make nike file; inike=0 => make dyna file
6   c .... imodel = 0 => full 3 segment model with interconnects
7   c          = 1 => 3-crown segment only
8   c          = 2 => 6-crown segment only
9   c          = 3 => 12-crown segment only
10  c .... isym = 0 => full 360 deg model
11  c          = 1 => symmetric model
12  c .... isim_mode:  type of simulation
13  c       = 1: => radial force to R_f = X% R_0, restoring stress mat'l
14  c       = 2: => flat plate force, restoring stress mat'l
15  c       = 3: => predelivery compression, loading stress mat'l
16  c       = 4: => initial expansion
17  c       = 5: => frequency analysis
18  c .... refine = X => add X elements via mseq in each direction
19  c                 of the cross section
20  c
21  parameter inike 1 ;
22  parameter imodel 0 ;
23  parameter isym 0 ;
24  parameter isim_mode 4 ;
25  parameter refine 2 ;
26  c
27  para Tighten [0.9];      c helps 'tighten' or stiffen spline
28                           c  range (0.5,1) (probably should not change)
29  c
30  c -------------------- parameter settings -------------------
31  c
32  c ....  ======== design parameters ==========
33  c
34  c Note:  Adjust specified OD for each segment considering the wall
35  c        thickness for that segment so that ID's match in a consistent
36  c        way for the tube blank from which they were cut.
37  c
38  c Upper segment ---  3 crowns
39  c Middle segment --  6 crowns
```

FIG. 5B

```
Line  Command
40    c Lower segment --- 12 crowns (conical)
41    c
42    c Parameters for 3-crown segment
43    c
44    para
45     RCyl3 [.5*2/25.4]
46       dCIA3 [-.00]  c delta of center of inner arc for 3 crown segment (-:0)
47       dCOA3 [0]     c delta of center of outer arc for 3 crown segment (0:+)
48       CW3 [.007]    c Circumferential width of segments for 3 crowns
49       RW3 [.005]    c Radial width for 3 crowns
50       NRA3 [.0095]  c normal radius of smaller cylinders (arcs)
51                     c  for 3 crowns
52       Ht3 [0.224]   c distance from center of upper arcs
53                     c  to center of lower arcs for 3 crowns
54       NLegEl3 [12]; c number of elements along the leg
55
56    c
57    c Parameters for 6-crown segment
58    c
59    para
60       RCyl6 [.5*2/25.4]  c outside radius for 6 crown segment
61       dCIA6 [0]     c delta of center of inner (smaller) arc for 6 crown
                         segment(-:0)
62       dCOA6 [0.002]  c delta of center of outer (larger) arc for 6 crown
                           segment (0:+)
63       CW6 [.009]    c Circumferential width of segments for 6 crowns
64       RW6 [.009]    c Radial width for 6 crowns
65       NRA6 [.0105]  c normal radius of smaller cylinders (arcs)
66                     c  for 6 crowns
67       Ht6 [.115]    c distance from center of upper arcs
68                     c  to center of lower arcs for 6 crowns
69       NLegEl6 [12]; c number of elements along the leg
70
71    c
72    c Parameters for 12-crown segment
73    c
74    para
75       dCIA12 [0]       c delta of center of inner arc for 12 crown segment (-:0)
```

FIG. 5C

```
Line  Command
76      dCOA12 [0]       c delta of center of outer arc for 12 crown segment
                              (0:+)
77      CW12 [.005]      c Circumferential width of segments for 12 crowns
78      RW12 [.008]      c Radial width for 12 crowns
79      NRA12 [.006]      c normal radius of smaller cylinders (arcs)
80                  c  for 12 crowns
81      Ht12 [.050]       c distance from center of upper arcs
82                  c  to center of lower arcs for 12 crowns
83                  c  (measured along the leg, not necessarily in
84                  c  the z direction)
85      c first outside radius for 12 crown segment (near other segments)
86      RCyl12_1 [.5*2/25.4 - (.016-%RW12)]
87      c second outside radius for 12 crown segment (bottom)
88      RCYl12_2 [.5*1.4/25.4 - (.016-%RW12)]
89    c
90      NLegEl12 [10];    c number of elements along the leg
91
92    c
93    c Interconnects
94    c
95
96    c
97    c Upper interconnects
98    c
99    para HIUp   [.02]    c height of interconnect
100       FRUp   [.005]    c fillet radius for blend
101       ICWUp  [.006]    c circumferential width
102       IRWUp3 [.005]    c radial width at 3-crown end
103       IRWUp6 [.006];   c radial width at 6-crown end
104
105   c
106   c S-interconnects
107   c
108   para SIVer [.01]    c vertical distance between upper or lower arc centers
109                 c  also the distance from the vertical mid-line to
110                 c  the first arc center
111       SIHor [.010]  c horizontal distance between upper two or
112                 c  lower two arc centers
113       SIr   [.004]   c arc radius
```

FIG. 5D

```
Line  Command
114       SIrO [%SIr+%ICWUp/2]  c outer radius
115       SIrI [%SIr-%ICWUp/2]; c inner radius
116
117   c
118   c Lower interconnects
119   c
120   para HILr    [.031]    c height of interconnect
121        FRLr    [.010]    c fillet radius for blend
122        ICWLr   [.007]    c circumferential width
123        IRWLr6  [.005]    c radial width at 6-crown end
124        IRWLr12 [.005];   c radial width at 12-crown end
125
126   c

127   c .... ========== design parameters ==========
128   c
129   c .... set cylinder ID & OD for compression
130   c
131   if (%isim_mode.le.3) then
132   parameter ricompcyl
          [1.1*max(%RCyl3,%RCyl6,%RCyl12_1,%RCyl12_2)] ;
133   parameter rocompcyl
          [1.4*max(%RCyl3,%RCyl6,%RCyl12_1,%RCyl12_2)] ;
134   c
135   c .... set cylinder ID & OD for expansion
136   c
137   elseif (%isim_mode.eq.4) then
138   parameter rocompcyl
          [0.95*(min(%RCyl3,%RCyl6,%RCyl12_1,%RCyl12_2)-%RW6)] ;
139   parameter ricompcyl
          [0.7*(min(%RCyl3,%RCyl6,%RCyl12_1,%RCyl12_2)-%RW6)] ;
140   endif
141   c
142   c
143   c Materials assignments
144   c
145   parameter matst12 3 ;
146   parameter matst6  4 ;
147   parameter matst3  5 ;
```

FIG. 5E

```
Line  Command
148   parameter mati126 6 ;
149   parameter mati63  7 ;
150   c
151   c
152   if (%isim_mode.eq.1) then
153      echo *** Radial Force Simulation ***
154   elseif (%isim_mode.eq.2) then
155      echo *** Flat Plate Force Simulation ***
156   elseif (%isim_mode.eq.3) then
157      echo *** Predelivery Compression Simulation ***
158   elseif (%isim_mode.eq.4) then
159      echo *** Initial Expansion Simulation ***
160   elseif (%isim_mode.eq.5) then
161      echo *** Natural Frequency Analysis ***
162   else
163      echo  !!! ERROR:  illegal isim_mode !!!
164      interrupt
165   endif
166   c
167   c ---------- analysis options ----------
168   title  stent initial expansion simulation
169   c
170   c    *** DYNA3D Analysis Options ***
171   c
172   if (%inike.eq.0) then
173    echo Making DYNA3D input file
174    dyna3d
175      dynaopts
176      term 5.0e-5
177      plti 1.e-6
178      prti 5.0e-6
179   c
180   c .... DR options
181   c
182     itrx 500
183     tolrx 1.0e-2
184     drdb
185   c
186   c .... thermal effects option - temp from load curve 1
```

FIG. 5F

```
Line  Command
187   c
188    teo 1
189   c
190    tssf 0.0
191   c
192   c print initial time step size
193   c
194   c prtflg 1
195   c
196   c .... turn off (0) or on (1) SAND database flag
197   c
198    edsdf 0
199   c
200    nrest 90000
201     nrunr 95000 ;
202   c
203   c .... DYNA3D discrete nodes impacting surface - stent to cyl
204   c              * one side (180 deg) *
205   c
206   sid 1 dni
207   c sfif
208   c mfif
209   pnlts 1.0e-0
210   pnltm 1.0e-0
211    ;
212   c
213   c .... DYNA3D discrete nodes impacting surface - stent to cyl
214   c              * opposite side *
215   c
216   c sid 2 dni
217   c sfif
218   c mfif
219   c pnlts 1.0e-4
220   c pnltm 1.0e-4
221   c  ;
222   c
223   c .... end DYNA3D commands
224   c
225   endif
```

FIG. 5G

```
Line  Command
226   c
227   c
228   c    *** NIKE3D Analysis Options ***
229   c
230   if (%inike.eq.1) then
231    echo Making NIKE3D input file . . .
232    nike3d
233    nikeopts
234     nstep 5
235     delt 0.2
236     anal stat
237   c
238   c .... step tol of 1e-8 seems OK for predel compression
239   c
240   if (%isim_mode.eq.1.or.%isim_mode.eq.2) then
241     dctol -1.0e-8
242   elseif (%isim_mode.eq.3) then
243     dctol -1.0e-6
244   endif
245   c
246   c .... max iterations per stiffness reform
247   c
248     nibsr 20
249   c
250   c .... max stiffness reforms per step
251   c
252     msrf 20 ;
253   c
254   c .... temperatures follow load curve 1
255   c    ** manually add tref=1.0 on matl 2 control card cols 26-35 **
256   c
257     teo 1
258   if (%isim_mode.eq.1.or.%isim_mode.eq.2) then
259     iprt 1
260   elseif (%isim_mode.eq.3.or.%isim_mode.eq.4) then
261     iprt 25
262   endif
263     iplt 1
264     nsbrr 1
```

FIG. 5H

```
Line  Command
265     stifcore 1
266     bfgscore
267     bwmo new
268     echo  Bandwidth minimization ACTIVATED with "NEW" option
269   c
270   c  element constitutive data incore
271   c
272     bfor 10
273     sfor 10
274     bef  11
275   c
276   c .... linear solver
277   c
278    lsolver fissle
279   c
280   c .... solid element stent contact surface
281   c
282   sid 1 sv
283   c
284   if (%isim_mode.eq.1) then
285   c
286   c
287    pnlt 1.0e-5
288   elseif (%isim_mode.eq.2) then
289    pnlt 0.00001
290   elseif (%isim_mode.eq.3) then
291   c
292   c .... essential to adjust penalty
293   c
294   pnlt 1.0e+4
295   elseif (%isim_mode.eq.4) then
296    pnlt 1.0e-5
297   c iaug 1 ;
298   endif
299    ;
300   c
301   c .... slidesurface between interconnects and segments
302   c
303   sid 2 tied
```

FIG. 5I

```
Line  Command
304    ;
305   c
306   c .... NIKE3D shell geometric stiffness (HL only)
307   c
308    segs 1 ;
309   c
310   c .... end NIKE3D section
311   c
312   endif
313   c
314   c .... symmetry planes
315   c
316   if (%isym.eq.1) then
317   c
318   c ....  Symmetric Model
319   c      theta=-60 and +60 symmetry to remove rigid body modes
320   c
321   c plane 1
322   c   0.0 0.0 0.0
323   c   [-sin(60)] [-cos(60)] 0.0
324   c     0.0005 symm ;
325   c plane 2
326   c   0.0 0.0 0.0
327   c   [-sin(60)] [cos(60)] 0.0
328   c     0.0005 symm ;
329   c
330   else
331   c
332   c .... symmetry planes to remove rigid body modes for full model
333   c
334   plane 1
335     0.0  0.0  0.0
336     1.0  0.0  0.0
337       .0005 symm ;
338   plane 2
339     0.0  0.0  0.0
340     0.0  1.0  0.0
341       .0005 symm ;
342   c plane 3
```

FIG. 5J

```
Line  Command
343   c  0.0  0.0  0.0
344   c  0.0  0.0  TBD
345   c    .0005 symm ;
346   endif
347   c
348   c
349   if (%inike.eq.0) then
350   c
351   c .... Load Curves for DYNA3D  **ADD DR FLAG TO INPUT FILE **
352   c
353   if (%isim_mode.eq.1) then
354   c
355   c .... radial force
356   c
357   lcd 1
358       0.000E+00 1.000E+00
359       7.500E-03 2.250E+04
360       1.000E-00 2.250E+04 ;
361   c   1.000E-02 3.000E+04
362   c   1.000E-00 3.000E+04 ;
363   elseif (%isim_mode.eq.2) then
364   c
365   c .... flat plate compression, lcd 1 not used (dummy definition)
366   c
367   quit
368   c
369   elseif (%isim_mode.eq.3) then
370   c
371   c .... predelivery compression strain
372   c
373   lcd 1
374       0.000E+00 1.000E+00
375       1.000E-02 2.008E+05
376       1.000E-00 2.008E+05 ;
377   endif
378   c
379   c .... load curve #2 only used for flat plate compression
380   c
381   lcd 2
```

FIG. 5K

```
Line  Command
382     0.000E+00  0.000E+00
383     1.000E+00  0.000e-00 ;
384   endif
385   c
386   if (%inike.eq.1) then
387   c
388   c .... ******** Load Curves for NIKE3D **********
389   c
390   if (%isim_mode.eq.1) then
391   c
392   c .... radial force
393   c
394   lcd 1
395       0.000E+00 1.000E+00
396       1.000E+00 2.000E+03 ;
397   elseif (%isim_mode.eq.2) then
398   c
399   c .... flat plate compression
400   c
401   lcd 1
402       0.000E+00 1.000E+00
403       1.000E+00 0.000E+00 ;
404   elseif (%isim_mode.eq.3) then
405   c
406   c .... predelivery compression strain
407   c
408   lcd 1
409       0.000E+00 1.000E+00
410       1.000E+00 2.008E+03 ;
411   elseif (%isim_mode.eq.4) then
412   c
413   c .... initial expansion strain
414   c
415   lcd 1
416   c .... thermal load (activate TEO above)
417   c    0.000E+00  1.000E+00
418   c    1.000E+00 -2.008E+04 ;
419   c .... prescribed displacement
420       0.000E+00  0.000E+00
```

FIG. 5L

```
Line  Command
421       1.000E+00  1.000E-02 ;
422   endif
423   c
424   c ------------------------- stent parts -----------------
425   c
426   include  irss.tg
427   c
428   c ------------------------- stent materials -----------------
429   c
430   if (%inike.eq.1) then
431         if (%isim_mode.eq.1.or.%isim_mode.eq.2) then
432            include istent.mats_nike_solid
433            echo   model for radial force/flat plate analysis
434         elseif (%isim_mode.eq.3) then
435            include istent.mats_compress_nike_solid
436            echo   model for predelivery compression strain
437         elseif (%isim_mode.eq.4) then
438            include istent.mats_compress_nike_solid
439            echo   model for initial expansion strain
440         endif
441   c
442   elseif (%inike.eq.0) then
443         if (%isim_mode.eq.1.or.%isim_mode.eq.2) then
444            include istent.mats_dyna_solid
445            echo   model for radial force/flat plate analysis
446         elseif (%isim_mode.eq.3) then
447            include istent.mats_compress_dyna_solid
448            echo   model for predelivery compression strain
449         elseif (%isim_mode.eq.4) then
450            include istent.mats_compress_dyna_solid
451            echo   model for initial expansion strain
452         endif
453   endif
454   c
455   c .... cylindrical compression for radial force or predelivery compression
456   c
457   if (%isim_mode.eq.1.or.%isim_mode.eq.3.or.%isim_mode.eq.4) then
458   c
459      if (%isym.eq.1) then
```

```
Line  Command
460         include cylinder.parts_sym
461       else
462         include cylinder.parts
463       endif
464   c
465   if (%inike.eq.1) then
466     include cylinder.materials_nike
467   elseif (%inike.eq.0) then
468     include cylinder.materials_dyna
469   endif
470   endif
471   c
472   stp .01
473   merge
474   c
```

FIG. 5M

```
1   c ********** TPEG Inflatable Proximal Seal Simulation ******************
2   c                  (seal.run)
3   c                  March, 1999
4   c
5   c -------------------- parameter settings -------------------
6   c
7   c .... analytical model aorta geometric parameters
8   c      (distortion is 4-lobe)
9   c
10  parameter r_aorta [10.0/25.4] ;
11  parameter thk_aorta [1.0/25.4] ;
12  parameter amp_plaque [0.0/25.4] ;
13  c
14  parameter ro_aorta [%r_aorta+%thk_aorta] ;
15  c
16  c ....  -- TPEG Design Parameters --
17  c
18  parameter r_tpeg [10/25.4] ;
19  parameter r_ps [3/25.4] ;
20  parameter l_tpeg 2.0 ;
21  parameter l_flap 0.25 ;
22  c
23  parameter graft_wall_thick [6*0.0013] ;
24  parameter cuff_wall_thick  [3*0.0013] ;
25  parameter flap_wall_thick  [6*0.0013] ;
26  c
27  c
28  c .... Pressures and load curve assignments
29  c
30  parameter P_hemo 2.32 ;
31  parameter P_cuff 3.0 ;
32  c
33  parameter lc_hemo 1 ;
34  parameter lc_proxcuff 3 ;
35  c
36  c .... TPEG folding simulation parameters
37  c
38  parameter vel_fold 20.0 ;
39  parameter t_fold [0.25/%vel_fold] ;
40  parameter t_init 0.0e-3 ;
41  c
42  c
```

FIG. 6A

```
c ---------- analysis options ----------
title sc6.i Seal CT-Solid r_t=10mm r_ps=3mm  P_cuff=3.0 990428
c
c    *** DYNA3D Analysis Options ***
c
dyna3d
dynaopts
 term 6.5e-2
 plti 5.e-4
 prti 2.5e-2
c
c .... DR options
c
itrx 500
c
c .... increase DR tol to prevent convergence after compression before expansion
c
c tolrx 1.0e-6
tolrx 1.0e-12
drdb
c
 tssf 0.9
c
c .... turn off (0) or on (1) SAND database flag
c
  edsdf 0
c
  nrest 90000
  nrunr  5000 ;
c
c .... symmetry planes on xz and yz planes
c
plane 1
  0.0 0.0 0.0
  1.0 0.0 0.0    0.001    symm ;
plane 2
  0.0 0.0 0.0
  0.0 1.0 0.0    0.001    symm ;
c
c .... DYNA3D slidesurface:  +x folder cylinder
c
sid 1 sv
```

FIG. 6B

FIG. 6C

```
85      pnlts 1.0
86      pnltm 1.0
87      pen
88       ;
89      c
90      c .... DYNA3D slidesurface:  -x folder cylinder
91      c
92      sid 2 sv
93      pnlts 1.0
94      pnltm 1.0
95      pen
96       ;
97      c
98      c
99      c .... DYNA3D slidesurface:  +y folder cylinder
100     c
101     sid 3 sv
102     pnlts 1.0
103     pnltm 1.0
104     pen
105      ;
106     c
107     c .... DYNA3D slidesurface:  -y folder cylinder
108     c
109     sid 4 sv
110     pnlts 1.0
111     pnltm 1.0
112     pen
113      ;
114     c
115     c .... DYNA3D tpeg to aorta (aorta is master)
116     c
117     sid 5 sv
118     c
119     c .... solid element aorta
120     c
121     pnlts 0.1
122     pnltm 0.1
123     c
124     c .... shell element aorta
125     c
126     c pnlts 1.0
```

FIG. 6D

```
127   c pnltm 1.0
128   pen
129    ;
130   c
131   c .... load curve:  hemodynamics  **** ADD DR FLAG TO INPUT FILE ****
132   c
133   lcd 1
134    0.000E+00              0.000E+00
135    [%t_init+2*%t_fold+1.0e-3]  0.000e+00
136    [%t_init+2*%t_fold+2.0e-3]  %P_hemo
137    1.000E+00              %P_hemo ;
138   c
139   c .... load curve:  channel !! NOT USED !! **** ADD DR FLAG TO INPUT FILE ****
140   c
141   lcd 2
142    0.000E+00 0.000E+00
143    [%t_init+2*%t_fold+1.0e-3]  0.000e+00
144    [%t_init+2*%t_fold+2.0e-3]  0.000e-00
145    1.000E+00              0.000e-00 ;
146   c
147   c .... load curve: proximal cuff  **** ADD DR FLAG TO INPUT FILE ****
148   c
149   lcd 3
150    0.000E+00 0.000E+00
151    [%t_init+2*%t_fold+1.0e-3]  0.000e+00
152    [%t_init+2*%t_fold+2.0e-3]  %P_cuff
153    1.000E+00              %P_cuff ;
154   c
155   c .... load curve for +x folder cylinder motion/velocity
156   c
157   lcd 4
158    0.000E+00              0.000E+00
159    %t_init                0.000E+00
160    [%t_init+1.0E-04]          [-%vel_fold]
161    [%t_init+%t_fold]          [-%vel_fold]
162    [%t_init+%t_fold+1.0e-3]      0.000E+00
163    [%t_init+2*%t_fold+1.0e-3]    0.000e+00
164    [%t_init+2*%t_fold+2.0e-3]    [2.0*%vel_fold]
165    [%t_init+3*%t_fold+2.0e-3]    [2.0*%vel_fold]
166    [%t_init+3*%t_fold+3.0e-3]    0.000e+00
167    1.000E+00        0.000E+00 ;
168   c
```

FIG. 6E

```
c .... load curve for -x folder cylinder motion
c
lcd 5
 0.000E+00              0.000E+00
 %t_init              0.000E+00
 [%t_init+1.000E-04]      [ %vel_fold]
 [%t_init+%t_fold]        [ %vel_fold]
 [%t_init+%t_fold+1.0e-3]   0.000E+00
 [%t_init+2*%t_fold+1.0e-3]   0.000e+00
 [%t_init+2*%t_fold+2.0e-3]   [-2.0*%vel_fold]
 [%t_init+3*%t_fold+2.0e-3]   [-2.0*%vel_fold]
 [%t_init+3*%t_fold+3.0e-3]   0.000e+00
 1.000E+00              0.000E+00 ;
c
c .... load curve for +y folder cylinder motion
c
lcd 6
 0.000E+00              0.000E+00
 %t_init              0.000E+00
 [%t_init+1.000E-04]      [-%vel_fold]
 [%t_init+%t_fold]        [-%vel_fold]
 [%t_init+%t_fold+1.0e-3]   0.000E+00
 [%t_init+2*%t_fold+1.0e-3]   0.000e+00
 [%t_init+2*%t_fold+2.0e-3]   [2.0*%vel_fold]
 [%t_init+3*%t_fold+2.0e-3]   [2.0*%vel_fold]
 [%t_init+3*%t_fold+3.0e-3]   0.000e+00
 1.000E+00              0.000E+00 ;
c
c .... load curve for -y folder cylinder velocity
c
lcd 7
 0.000E+00              0.000E+00
 %t_init              0.000E+00
 [%t_init+1.000E-04]      [ %vel_fold]
 [%t_init+%t_fold]        [ %vel_fold]
 [%t_init+%t_fold+1.0e-3]   0.000E+00
 [%t_init+2*%t_fold+1.0e-3]   0.000e+00
 [%t_init+2*%t_fold+2.0e-3]   [-2.0*%vel_fold]
 [%t_init+3*%t_fold+2.0e-3]   [-2.0*%vel_fold]
 [%t_init+3*%t_fold+3.0e-3]   0.000e+00
 1.000E+00              0.000E+00 ;
c
```

FIG. 6F

```
211   c ------------------------- parts and materials -----------------
212   c
213   c
214   c .... get CT-data meshed aorta; convert cm to inches
215   c
216   csca [1./2.54]
217   include tpeg.part_ct_aorta3
218   c
219   csca 1.0
220   c
221   c .... option for analytical aorta model
222   c
223   c include tpeg.part_eq_aorta
224   c
225   include tpeg.part_cuff1
226   include tpeg.part_folder2
227   c
228   include tpeg.materials_dyna
229   c
230   c .... use negative tols to prevent aorta nodes merging w/ folder cylinder
231   c     nodes if they coincidently become adjacent
232   c
233   c .... merge nodes within CT aorta part using rather loose tolerance
234   c
235   bptol 1 1 0.01
236   bptol 1 3 -1.0
237   bptol 1 4 -1.0
238   bptol 1 5 -1.0
239   bptol 1 6 -1.0
240   tp .001
241   c
```

FIG. 7A

```
1     c
2     c              tpeg.part_ct_aorta3
3     c               April 15, 1999
4     c
5     c -------  Aortic Model for Inflatable TPEG Model ---------
6     c          Derived from Patient CT Data
7     c          Outer surface constructed with 0.52 mm offset from inner
8     c
9     c .... this is an aortic mesh file which surrounds the neck of the
10    c     3-D AAA reconstruction with solid elements.
11    c
12    c     This file uses TrueGrid planes, oriented by eye using trial
13    c     and error graphically, to determine an orthonormal section.
14    c     Trick there is to adjust surface until walls of proximal neck section
15    c     are parallel to global z axis.  Use rz to rotate screen to find values,
16    c     then use in surface transformation to position CT data for meshing.
17    c
18    c .... import IGES file containing surface data from CT scan
19    c
20    iges solid1.igs 1 1 mx -18.54 my -16.8     ry 24 rx 22 mz  4.8;
21    c
22    c .... inner surface
23    c
24    sd 17 sds 9 12;
25    c
26    c .... outer surface
27    c
28    sd 18 sds 15 16 ;
29    c
30    sd 201 plan
31         0. 0. 1.5
32         0  0  1
33    sd 202 plan
34         0. 0. 2.5
35         0  0  1
36    sd 203 plan
37         0. 0. -2.3
38         0  0  1
39    sd 204 plan
40         0. 0. 3.3
41         0  0  1
42    sd 301 cy 0 0 0 0 0 1 1.35
```

FIG. 7B

```
43      sd 401 plan
44          0. 0. 0.
45          0. 1. 0.
46      c
47      c .... adjust mz to position part at cuff on Z-axis;
48      c         cuff may be z=[2,2.15]
49      cylinder
50        1 2;
51      1 2 3;
52      1 2 3 4 ;
53      c
54      1.0 1.25
55      0 180.0 360.0
56      -2.3 1.5 2.5 3.3
57      c
58      mseq i 2
59      mseq j 29 29
60      mseq k 20 5 5
61      c
62      c .... project top and bottom ends of aorta segment onto orthonormal planes
63      c
64      sfi ; ; -2;  sd 201
65      sfi ; ; -3;  sd 202
66      c
67      c .... project top of upper neck segment onto orthonormal plane
68      c
69      sfi ; ; -4;  sd 204
70      c
71      c .... project bottom of lower neck segment onto orthonormal plane
72      c      after radially expanding bottom ring by delta-r=2.0
73      mbi -1; ; -1; x 2.0
74      mbi -2; ; -1; x 2.0
75      sfi ; ; -1;  sd 203
76      c
77      c .... project inner cylinder surface onto aorta luminal surface
78      c
79      sfi -1; 1 3; 2 3; sd 17
80      sfi -1; 1 3; 3 4; sd 17
81      sfi -1; 1 3; 1 2; sd 17
82      c
83      c .... project outer cylinder onto aorta outer wall surface
84      c
```

FIG. 7C

```
85      sfi -2; 1 3; 2 3; sd 18
86      sfi -2; 1 3; 3 4; sd 18
87      sfi -2; 1 3; 1 2; sd 18
88      c
89      c .... project theta=0/360 seam onto a plane to facilitate merging
90      c
91      sfi 1 2; -1; ;  sd 401
92      sfi 1 2; -3; ;  sd 401
93      c
94      c
95      c ... --- slidesurface definition with TPEG body ---
96      c
97      orpt + 0. 0. 3.0
98      sii  -1; 1 3; 3 4;  5 m
99      c
100     c .... +y hemicylinder is material 11; -y is mat 12
101     c
102     mti ; 1 2; 2 4 ;  11
103     mti ; 2 3; 2 4;  12
104     c
105     c .... rigid material for aneurysm sac
106     c
107     mti ; 1 3; 1 2;  13
108     c
109     c .... Boundary Conditions
110     c     * fix proximal end only in z
111     c
112     bi ; ; -4;  dz 1 ;
113     c
114     c .... adjust mz to position aorta at cuff on Z-axis;
115     c         cuff may be z=[2,2.15]
116      lct 1
117         mz  [1.01*2.54] mx 0.7; ;
118      lrep 1 ;
119     endpart
120     c
```

FIG. 8A

```
1     c ****** Slotted Tube Integrated Stent Design Simulation *******
2     c                (istent.run)
3     c       Stent design analysis & CT-Anatomy simulation
4     c
5     c ------------------- parameter settings ------------------
6     c
7     c .... inike=1 => make nike file; inike=0 => make dyna file
8     c .... imodel = 0 => full 3 segment model with interconnects
9     c           = 1 => 3-crown segment only
10    c           = 2 => 6-crown segment only
11    c           = 3 => 12-crown segment only
12    c .... isym = 0 => full 360 deg model
13    c         = 1 => symmetric model
14    c .... isim_mode:  type of simulation
15    c       = 1: => radial force to R_f = 80% R_0, restoring stress mat'l
16    c       = 2: => flat plate force, restoring stress mat'l
17    c       = 3: => predelivery compression to 12 F, loading stress mat'l
18    c       = 4: => initial expansion
19    c       = 5: => frequency analysis
20    c       = 6: => anatomy deployment
21    c .... refine = X => add X elements via mseq in each direction
22    c                of the cross section
23    c
24    c  !!! warning - only 1st 8 characters of variable unique !!!!
25    c
26    parameter inike 1 ;
27    parameter imodel 2 ;
28    parameter isym 0 ;
29    parameter isim_mode 6 ;
30    parameter refine 1 ;
31    c
32    para Tighten [0.9];      c helps 'tighten' or stiffen spline
33                        c  range (0.5,1) (probably should not change)
34    c
35    c ------------------- parameter settings ------------------
36    c
37    c ....  ========== design parameters ==========
38    c
39    c  Note:  Adjust specified OD for each segment considering the wall thickness
40    c       for that segment so that ID's match in a consistent way for the
41    c       tube blank from which they were cut.
42    c
43    c Upper segment ---  3 crowns
44    c Middle segment --  6 crowns
45    c Lower segment --- 12 crowns (could be conical)
46    c
47    c Parameters for 3-crown segment
48    c
49    para
```

FIG. 8B

```
50      RCyl3 [29*0.5/25.4]
51        dCIA3 [-.00]  c delta of center of inner arc for 3 crown segment (-:0)
52        dCOA3 [0]     c delta of center of outer arc for 3 crown segment (0:+)
53        CW3 [.020]    c Circumferential width of segments for 3 crowns
54        RW3 [.018]    c Radial width for 3 crowns
55        NRA3 [.0195]  c normal radius of smaller cylinders (arcs)
56                  c   for 3 crowns
57        Ht3 [1.048]   c distance from center of upper arcs
58                  c   to center of lower arcs for 3 crowns
59        NLegEl3 [12]; c number of elements along the leg
60      c
61      c Parameters for 6-crown segment
62      c
63      para
64        RCyl6 [29*0.5/25.4]  c outside radius for 6 crown segment
65        dCIA6 [0]     c delta of center of inner (smaller) arc for 6 crown segment (-:0)
66        dCOA6 [0.005]  c delta of center of outer (larger) arc for 6 crown segment (0:+)
67        CW6 [.020]    c Circumferential width of segments for 6 crowns
68        RW6 [.018]    c Radial width for 6 crowns
69        NRA6 [.0195]  c normal radius of smaller cylinders (arcs)
70                  c   for 6 crowns
71        Ht6 [.310]    c distance from center of upper arcs
72                  c   to center of lower arcs for 6 crowns
73        NLegEl6 [12]; c number of elements along the leg
74      c
75      c Parameters for 12-crown segment
76      c
77      para
78        dCIA12 [0]      c delta of center of inner arc for 12 crown segment (-:0)
79        dCOA12 [0]      c delta of center of outer arc for 12 crown segment (0:+)
80        CW12 [.008]     c Circumferential width of segments for 12 crowns
81        RW12 [.008]     c Radial width for 12 crowns
82        NRA12 [.006]    c normal radius of smaller cylinders (arcs)
83                  c   for 12 crowns
84        Ht12 [.164]     c distance from center of upper arcs
85                  c   to center of lower arcs for 12 crowns
86                  c   (measured along the leg, not necessarily in
87                  c   the z direction)
88        c first outside radius for 12 crown segment (near other segments)
89        RCyl12_1 [22*0.5/25.4]
90        c second outside radius for 12 crown segment (bottom)
91        RCYl12_2 [20*0.5/25.4]
92      c
93        NLegEl12 [10];   c number of elements along the leg
94      c
95      c Interconnects
96      c
97      c Upper interconnects
98      c
```

FIG. 8C

```
99      para
100     c   HIUp   [.10]    c height of interconnect
101         HIUp   [.20]    c height of interconnect
102         FRUp   [.016]    c fillet radius for blend
103         ICWUp  [.010]    c circumferential width
104         IRWUp3 [.016]    c radial width at 3-crown end
105         IRWUp6 [.016];   c radial width at 6-crown end
106     c
107     c S-interconnects
108     c
109     para
110     c   SIVer [.03]    c vertical distance between upper or lower arc centers
111         SIVer [.06]    c vertical distance between upper or lower arc centers
112                    c   also the distance from the vertical mid-line to
113                    c   the first arc center
114         SIHor [.0125]  c horizontal distance between upper two or
115                    c   lower two arc centers
116         SIr   [.008]   c arc radius
117         SIrO [%SIr+%ICWUp/2]  c outer radius
118         SIrI [%SIr-%ICWUp/2]; c inner radius
119     c
120     c Lower interconnects
121     para
122     c   HILr   [.071]   c height of interconnect
123         HILr   [.142]   c height of interconnect
124         FRLr   [.016]   c fillet radius for blend
125         ICWLr  [.016]   c circumferential width
126         IRWLr6  [.005]   c radial width at 6-crown end
127         IRWLr12 [.005];  c radial width at 12-crown end
128     c
129     c .... ========== design parameters ==========
130     c
131     c .... set cylinder ID & OD for compression
132     c
133     if (%isim_mode.le.3.or.%isim_mode.eq.6) then
134     parameter ricompcyl [1.1*max(%RCyl3,%RCyl6,%RCyl12_1,%RCyl12_2)] ;
135     parameter rocompcyl [1.4*max(%RCyl3,%RCyl6,%RCyl12_1,%RCyl12_2)] ;
136     c
137     c .... set cylinder ID & OD for expansion
138     c
139     elseif (%isim_mode.eq.4) then
140     parameter rocompcyl [0.95*(min(%RCyl3,%RCyl6,%RCyl12_1,%RCyl12_2)-%RW6)] ;
141     parameter ricompcyl [0.7* (min(%RCyl3,%RCyl6,%RCyl12_1,%RCyl12_2)-%RW6)] ;
142     endif
143     c
144     c Materials assignments
145     c
146     parameter matst12 3 ;
147     parameter matst6  4 ;
```

FIG. 8D

```
148   parameter matst3  5 ;
149   parameter mati126 6 ;
150   parameter mati63  7 ;
151   c
152   if (%isim_mode.eq.1) then
153     echo *** Radial Force Simulation ***
154   elseif (%isim_mode.eq.2) then
155     echo *** Flat Plate Force Simulation ***
156   elseif (%isim_mode.eq.3) then
157     echo *** Predelivery Compression Simulation ***
158   elseif (%isim_mode.eq.4) then
159     echo *** Initial Expansion Simulation ***
160   elseif (%isim_mode.eq.5) then
161     echo *** Natural Frequency Analysis ***
162   elseif (%isim_mode.eq.6) then
163     echo *** Anatomy Deployment Simulation***
164   else
165     echo  !!! ERROR:  illegal isim_mode !!!
166     interrupt
167   endif
168   c
169   c ------------------- analysis options -----------------
170   title human-size stent anatomy deployment
171   c
172   c    *** DYNA3D Analysis Options ***
173   c
174   if (%inike.eq.0) then
175    echo Making DYNA3D input file
176    dyna3d
177      dynaopts
178      term 2.0e-4
179      plti 1.e-4
180      prti 5.0e-6
181   c
182   c .... DR options
183   c
184   c itrx 500
185   c tolrx 1.0e-6
186   c drdb
187   c
188   c .... thermal effects option - temp from load curve 1
189   c
190   if (%isim_mode.ne.5)  then
191    teo 1
192   endif
193   c
194    tssf 0.0
195   c
196   c print initial time step size
```

FIG. 8E

```
197   c
198   c prtflg 1
199   c
200   c .... turn off (0) or on (1) SAND database flag
201   c
202    edsdf 0
203   c
204    nrest 90000
205     nrunr 95000 ;
206   c
207   c .... DYNA3D stent to compression cyl
208   c
209   sid 1 dni
210   c sfif
211   c mfif
212   pnlts 1.0e-0
213   pnltm 1.0e-0
214    ;
215   c
216   c .... DYNA3D tied interface to interconnects if multisegment
217   c
218   if (%imodel.eq.0) then
219   sid 2 tied
220     ;
221   endif
222   c
223   c .... end DYNA3D commands
224   c
225   endif
226   c
227   c    *** NIKE3D Analysis Options ***
228   c
229   if (%inike.eq.1) then
230     echo Making NIKE3D input file . . .
231     nike3d
232     nikeopts
233   c
234   c .... temperatures follow load curve 1
235   c    ** manually add tref=1.0 on matl 2 control card cols 26-35 **
236   c
237     teo 1
238   c
239   if (%isim_mode.eq.5) then
240     anal dyn
241     neig 20
242     shift 69
243     iplt 1
244     nsbrr 1
245     stifcore 1
```

FIG. 8F

```
246       bfgscore
247       bwmo new
248     c
249     c  element constitutive data incore
250     c
251       bfor 10
252       sfor 10
253       bef  11
254     c
255     c .... linear solver
256     c
257       lsolver fissle
258     c
259     elseif (%isim_mode.ne.5) then
260     c
261     c .... time step analysis
262     c
263       nstep 100
264       delt 0.0100
265       anal stat
266     c
267     c .... step tol of 1e-2 is OK for predel compression
268     c
269     if (%isim_mode.eq.1.or.%isim_mode.eq.2) then
270       dctol -1.0e-3
271     elseif (%isim_mode.eq.3) then
272       dctol -1.0e-2
273     endif
274     c
275     c .... max iterations per stiffness reform
276     c
277       nibsr 20
278     c
279     c .... max stiffness reforms per step
280     c
281       msrf 20 ;
282     if (%isim_mode.eq.1.or.%isim_mode.eq.2) then
283       iprt 1
284     elseif (%isim_mode.eq.3.or.%isim_mode.eq.4) then
285       iprt 25
286     endif
287       iplt 1
288       nsbrr 1
289       stifcore 1
290       bfgscore
291       bwmo new
292       echo  Bandwidth minimization ACTIVATED with "NEW" option
293     c
294     c  element constitutive data incore
```

FIG. 8G

```
c
  bfor 10
  sfor 10
  bef  11
c
c .... linear solver
c
 lsolver fissle
c
c .... solid element stent contact surface
c
sid 1 sv
c
if (%isim_mode.eq.1) then
c
c .... below changed for sharp-edge laser-cut stent
c
 pnlt 1.0e-3
elseif (%isim_mode.eq.2) then
 pnlt 0.01
elseif (%isim_mode.eq.3) then
c
c .... essential to cut penalty for laser-cut stent predel compression
c
pnlt 0.001
elseif (%isim_mode.eq.4) then
 pnlt 1.0e-3
c iaug 1 ;
endif
 ;
c
c .... end block for time step only analysis
c
endif
c
c .... slidesurface between interconnects and segments
c
sid 2 tied
  ;
c
c .... slidesurface between stent and aortic wall
c
if (%isim_mode.eq.6) then
echo *** Add activation time of 0.5 to slidesurface 2 ***
sid 3 sv
;
endif
c
c .... NIKE3D shell geometric stiffness (HL only)
```

FIG. 8H

```
344   c
345     segs 1 ;
346     c
347     c .... end NIKE3D section
348     c
349     endif
350     c
351     c .... symmetry planes (omit for freq analysis)
352     c
353     if (%isim_mode.ne.5) then
354     if (%isym.eq.1) then
355     c
356     c ....  Symmetric Model
357     c
358     c plane 1
359     c   0.0 0.0 0.0
360     c   [-sin(60)] [-cos(60)] 0.0
361     c     0.0005 symm ;
362     c plane 2
363     c   0.0 0.0 0.0
364     c   [-sin(60)] [cos(60)] 0.0
365     c     0.0005 symm ;
366     c
367     else
368     c
369     c .... symmetry planes to remove rigid body modes for full model
370     c
371     plane 1
372       0.0  0.0  0.0
373       1.0  0.0  0.0
374         .0005 symm ;
375     plane 2
376       0.0  0.0  0.0
377       0.0  1.0  0.0
378         .0005 symm ;
379     endif
380     endif
381     c
382     c
383     if (%inike.eq.0) then
384     c
385     c .... Load Curves for DYNA3D  **** ADD DR FLAG TO INPUT FILE ****
386     c
387     if (%isim_mode.eq.1) then
388     c
389     c .... radial force
390     c
391     lcd 1
392         0.000E+00 1.000E+00
```

FIG. 8I

```
393       7.500E-03 2.250E+02
394       1.000E-00 2.250E+02 ;
395    elseif (%isim_mode.eq.2) then
396    c
397    c .... flat plate compression, lcd 1 not used (dummy definition)
398    c
399    echo  !!! Flat plate not implemented for DYNA3D !!!
400    quit
401    c
402    elseif (%isim_mode.eq.3) then
403    c
404    c .... predelivery compression strain - 0.87 in. dia compressed to 12F
405    c        [check x-displ of stent center node to verify]
406    c
407    lcd 1
408       0.000E+00 1.000E+00
409       1.000E-02 1.008E+03
410       1.000E-00 1.008E+03 ;
411    elseif (%isim_mode.eq.6) then
412    c
413    c .... anatomy deployment
414    c      (LC from radial comp)
415    c
416    lcd 1
417       0.000E+00 1.000E+00
418       7.500E-04 1.000E+03
419       9.000E-04 1.000E+03
420       1.500E-03 1.000E+00
421       1.000E-00 1.000E+00 ;
422    endif
423    c
424    c .... load curve #2 only used for flat plate compression
425    c
426    lcd 2
427      0.000E+00  0.000E+00
428      1.000E+00  0.000e-00 ;
429    endif
430    c
431    if (%inike.eq.1) then
432    c
433    c .... ******** Load Curves for NIKE3D **********
434    c
435    if (%isim_mode.eq.1) then
436    c
437    c .... radial force
438    c
439    lcd 1
440       0.000E+00 1.000E+00
441       1.000E+00 3.000E+02 ;
```

FIG. 8J

```
442   elseif (%isim_mode.eq.2) then
443   c
444   c .... flat plate compression, lcd 1 not used (dummy definition)
445   c
446   lcd 1
447      0.000E+00 1.000E+00
448      1.000E+00 0.000E+00 ;
449   elseif (%isim_mode.eq.3) then
450   c
451   c .... predelivery compression strain - 0.87 in. dia compressed to 12F
452   c        [check x-displ of stent center node to verify]
453   c
454   lcd 1
455      0.000E+00 1.000E+00
456      1.000E+00 1.008E+03 ;
457   elseif (%isim_mode.eq.4) then
458   c
459   c .... initial expansion strain - 4/5 mm OD to 15/27 mm OD
460   c        [check x-displ of stent center node to verify]
461   c
462   lcd 1
463   c .... thermal load (activate TEO above)
464      0.000E+00  1.000E+00
465      1.000E+00 -1.008E+03 ;
466   c .... prescribed displacement
467   c   0.000E+00  0.000E+00
468   c   1.000E+00  1.000E-01 ;
469   c
470   elseif (%isim_mode.eq.5) then
471   c
472   c .... must define load curve since TEO active even if unused for freq
473   c
474   c .... initial expansion strain - 4/5 mm OD to 15/27 mm OD
475   c        [check x-displ of stent center node to verify]
476   c
477   lcd 1
478   c .... thermal load (activate TEO above)
479      0.000E+00  1.000E+00
480      1.000E+00 -1.008E+03 ;
481   elseif (%isim_mode.eq.6) then
482   c
483   c .... anatomy deployment - 0.87 in. dia compressed to 12F
484   c
485   lcd 1
486      0.000E+00 1.000E+00
487      0.500E+00 5.000E+02
488      1.000E+00 1.000E+00 ;
489   endif
490   endif
```

FIG. 8K

```
491   c
492   c ------------------------- stent parts -----------------
493   c
494   include  irss.tg
495   c
496   c ------------------------- anatomy parts -----------------
497   c
498   if (%isim_mode.eq.6) then
499   c
500   c .... convert anatomy data from cm to inch units
501   c
502   control
503   csca [1./2.54]
504   c
505   c .... import meshed anatomy data for stent deployment
506   c        (this is an aortic stent)
507   c
508   include tpeg.part_ct_aorta3
509   csca 1.0
510   merge
511   if (%inike.eq.1) then
512   c
513   c .... set material properties for aortic wall
514   c
515   include aorta.materials_nike
516   endif
517   endif
518   c
519   c ------------------------- stent materials -----------------
520   c
521   if (%inike.eq.1) then
522         if (%isim_mode.eq.1.or.%isim_mode.eq.2) then
523            include istent.mats_nike_solid
524            echo  NiTi model for radial force/flat plate analysis
525         elseif (%isim_mode.eq.3) then
526            include istent.mats_compress_nike_solid
527            echo  NiTi model for predelivery compression strain
528         elseif (%isim_mode.eq.4) then
529            include istent.mats_compress_nike_solid
530            echo  NiTi model for initial expansion strain
531         elseif (%isim_mode.eq.5) then
532            include istent.mats_nike_freq_solid
533            echo  NiTi model for frequency analysis
534         elseif (%isim_mode.eq.6) then
535            include istent.mats_nike_solid
536            echo  NiTi model for anatomy deployment
537         endif
538   c
539   elseif (%inike.eq.0) then
```

FIG. 8L

```
      if (%isim_mode.eq.1.or.%isim_mode.eq.2) then
        include istent.mats_dyna_solid
        echo  NiTi model for radial force/flat plate analysis
      elseif (%isim_mode.eq.3) then
        include istent.mats_compress_dyna_solid
        echo  NiTi model for predelivery compression strain
      elseif (%isim_mode.eq.4) then
        include istent.mats_compress_dyna_solid
        echo  NiTi model for initial expansion strain
      elseif (%isim_mode.eq.6) then
        include istent.mats_compress_dyna_solid
        echo  NiTi model for anatomy deployment
      endif
endif
c
c .... cylindrical compression for radial force or predelivery compression
c
if (%isim_mode.eq.1.or.%isim_mode.eq.3.or.%isim_mode.eq.4.or.%isim_mode.eq.6) then
c
  if (%isym.eq.1) then
    include cylinder.parts_sym
  else
    include cylinder.parts
  endif
  endif
c
if (%inike.eq.1) then
  include cylinder.materials_nike
elseif (%inike.eq.0) then
  include cylinder.materials_dyna
endif
c
stp .0001
c
c .... Constrain stent node(s) in z-direction for time-hist analysis
c
if (%isim_mode.ne.5) then
merge
c
c .... nset for 3-segment model
c nset zconstr = l 8149 8687 9215 9747  ;
c echo  ** Bottom 12-crown node list Constrained in Z-translation **
c
c .... nset for 6-crown only
echo  ** Bottom 6-crown node list constrained in z-dir **
nset zconstr = l 43 97 151 448  ;
b nset zconstr dz 1 ;
endif
c
```

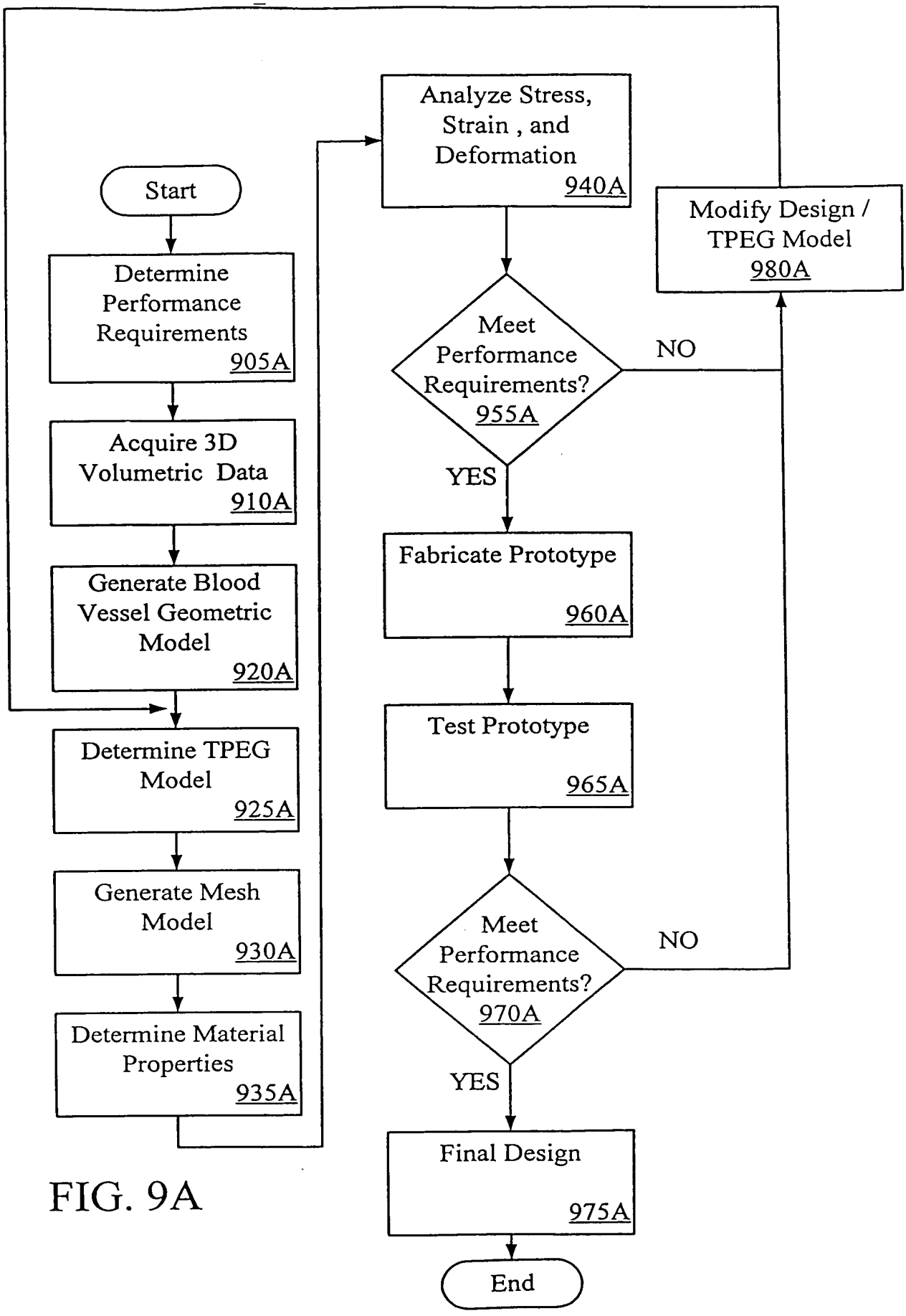

Start
Determine Performance Requirements 905A
Acquire 3D Volumetric Data 910A
Generate Blood Vessel Geometric Model 920A
Determine TPEG Model 925A
Generate Mesh Model 930A
Determine Material Properties 935A
Analyze Stress, Strain , and Deformation 940A
Meet Performance Requirements? 955A
NO
YES
Modify Design / TPEG Model 980A
Fabricate Prototype 960A
Test Prototype 965A
Meet Performance Requirements? 970A
NO
YES
Final Design 975A
End

FIG. 9A

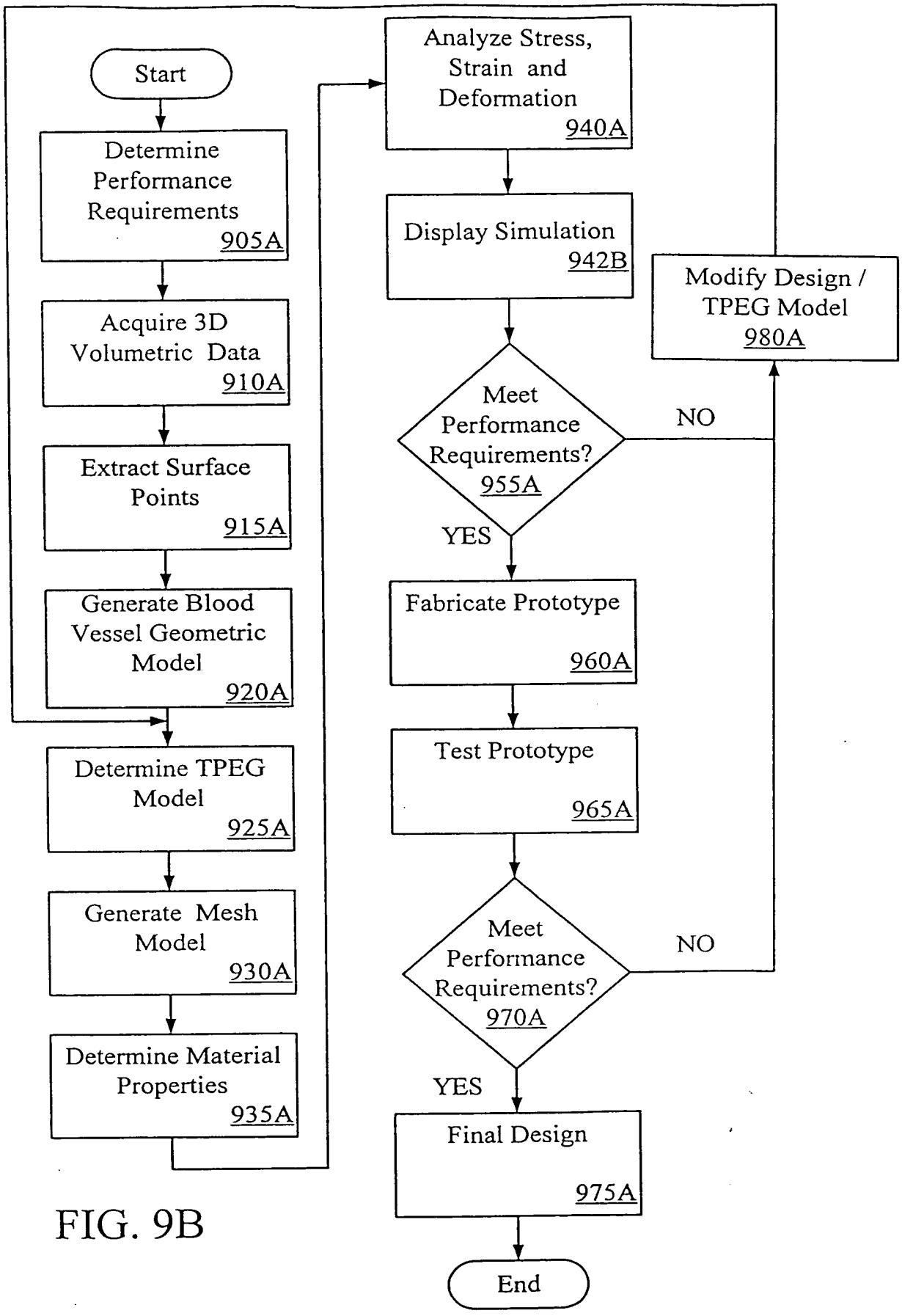

Start
Determine Performance Requirements 905A
Acquire 3D Volumetric Data 910A
Extract Surface Points 915A
Generate Blood Vessel Geometric Model 920A
Determine TPEG Model 925A
Generate Mesh Model 930A
Determine Material Properties 935A
Analyze Stress, Strain and Deformation 940A
Display Simulation 942B
Meet Performance Requirements? 955A
NO
YES
Modify Design / TPEG Model 980A
Fabricate Prototype 960A
Test Prototype 965A
Meet Performance Requirements? 970A
NO
YES
Final Design 975A
End

FIG. 9B

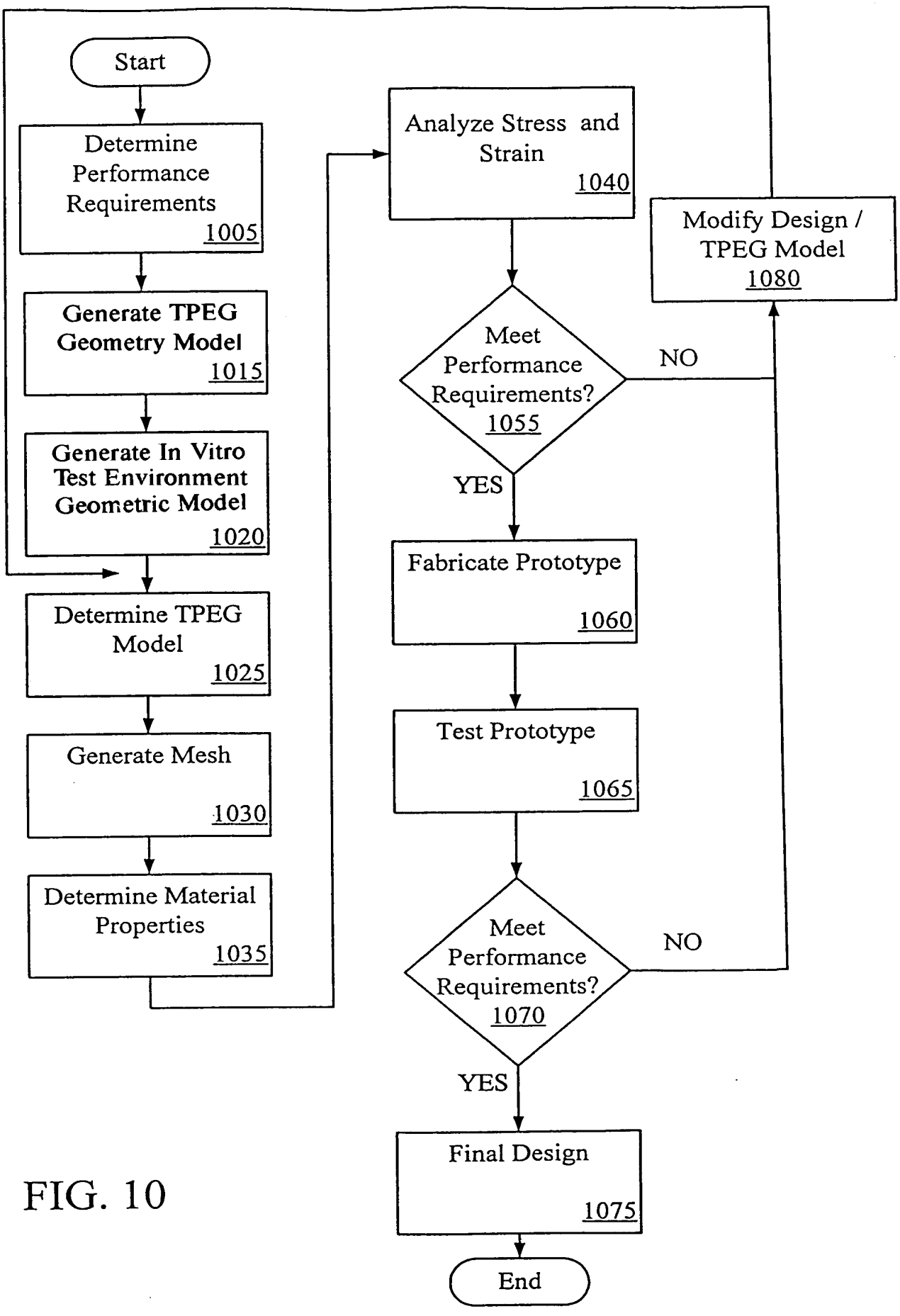

Start
Determine Performance Requirements 1005
Generate TPEG Geometry Model 1015
Generate In Vitro Test Environment Geometric Model 1020
Determine TPEG Model 1025
Generate Mesh 1030
Determine Material Properties 1035
Analyze Stress and Strain 1040
Meet Performance Requirements? 1055
NO
YES
Modify Design / TPEG Model 1080
Fabricate Prototype 1060
Test Prototype 1065
Meet Performance Requirements? 1070
NO
YES
Final Design 1075
End

FIG. 10

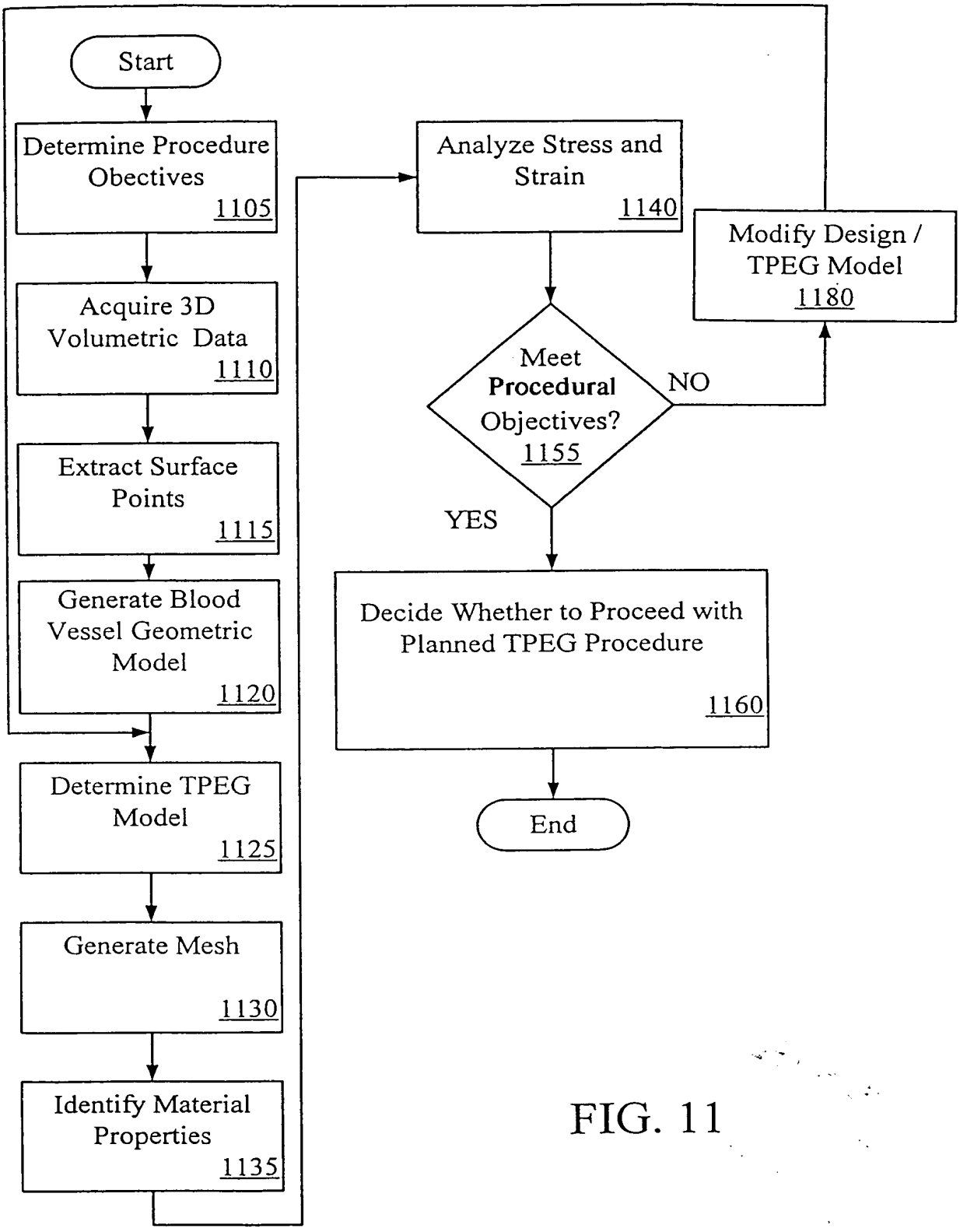

Start
Determine Procedure Obectives 1105
Acquire 3D Volumetric Data 1110
Extract Surface Points 1115
Generate Blood Vessel Geometric Model 1120
Determine TPEG Model 1125
Generate Mesh 1130
Identify Material Properties 1135
Analyze Stress and Strain 1140
Meet Procedural Objectives? 1155
NO
Modify Design / TPEG Model 1180
YES
Decide Whether to Proceed with Planned TPEG Procedure 1160
End

FIG. 11

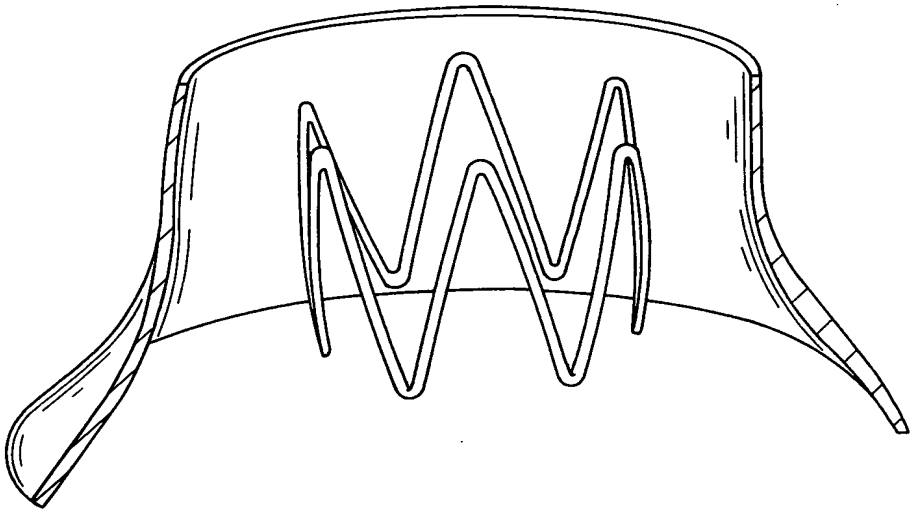
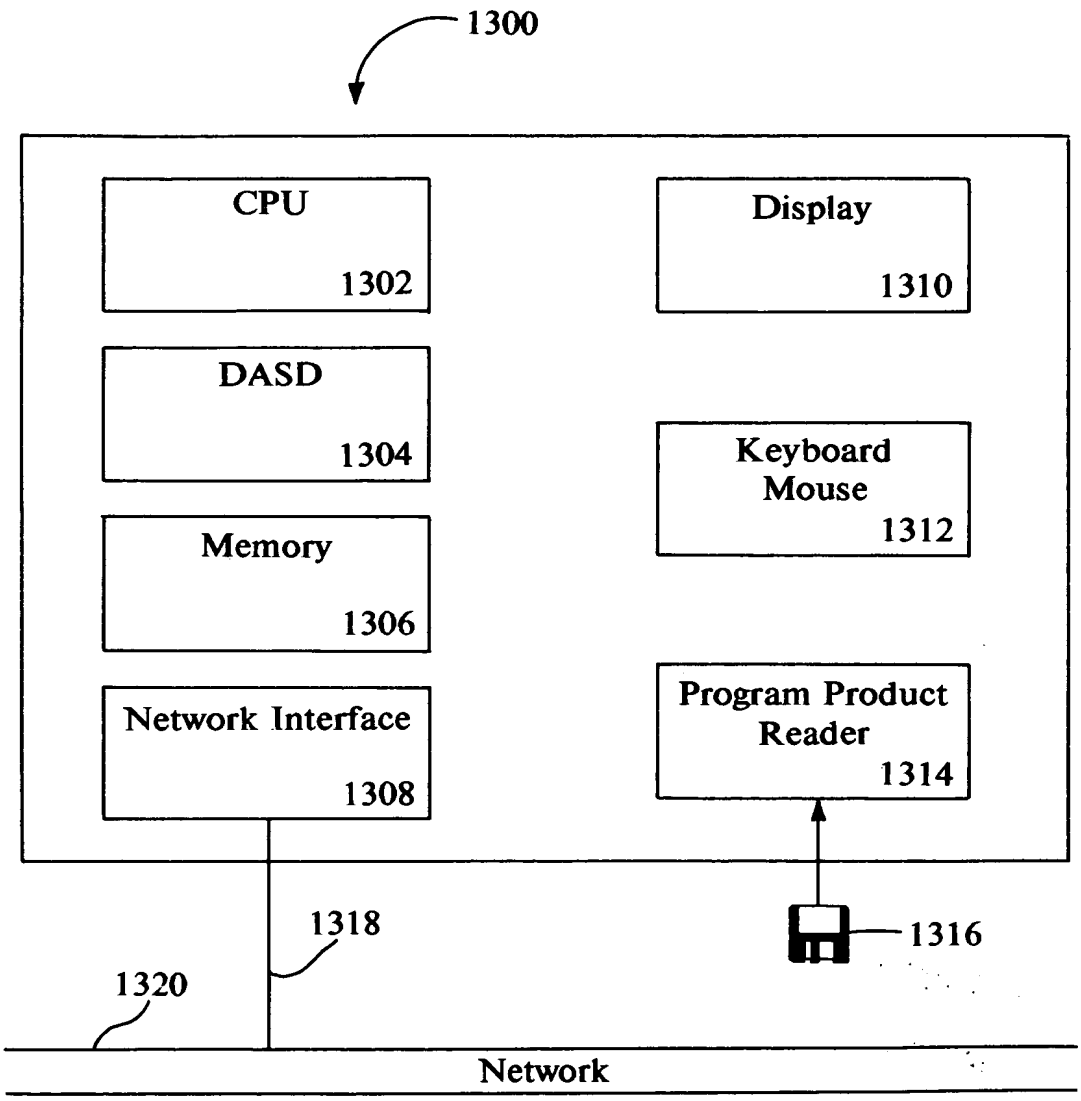


FIG. 12

FIG. 13


1300
CPU
1302
Display
1310
DASD
1304
Keyboard
Mouse
1312
Memory
1306
Network Interface
1308
Program Product
Reader
1314
1318
1316
1320
Network